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FOR

A METHOD AND APPARATUS TO FACILITATE SEPARATION OF A MASK AND A MASK PLATFORM

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A METHOD AND APPARATUS TO FACILITATE SEPARATION OF A MASK AND A MASK PLATFORM

TECHNICAL FIELD

[0001] The invention generally relates to methods and apparatus for lithography, in particular, method and apparatus to facilitate separation of a mask and a mask platform in an extreme ultraviolet lithography environment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The various embodiments of the invention is illustrated by way of example and not by way of limitation in the figures of the accompanying drawings, in which the like references indicate similar elements and in which:

[0003] **Figure 1** illustrates a simplified side view of an apparatus, in accordance with one embodiment of the invention;

[0004] **Figure 2** illustrates an apparatus for facilitating separation of a mask and a mask platform, in accordance with another embodiment;

[0005] **Figures 3a-3b** illustrate various views of an apparatus for facilitating separation of a mask and a mask platform, in accordance with another embodiment; and

[0006] **Figure 4** illustrates an apparatus for facilitating separation of a mask and a mask platform, in accordance with another embodiment.

DETAILED DESCRIPTION

[0007] In various embodiments, a method and apparatus to facilitate separation of a mask and a mask platform are described. In the following description, various embodiments will be described. However, one skilled in the relevant art will recognize that the various embodiments may be practiced without one or more of the specific details, or with other methods, materials, components, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of various embodiments of the invention. Similarly, for purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of the invention. Nevertheless, the invention may be practiced without the specific details. In other instances, well-known features are omitted or simplified in order not to obscure the invention. Furthermore, it is understood that the various embodiments shown in the figures are illustrative representations and are not necessarily drawn to scale.

[0008] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, material, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment or invention. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments.

[0009] Various operations will be described as multiple discrete operations in turn, in a manner that is most helpful in understanding the invention. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations need not be performed in the order of presentation.

[0010] **Figure 1** illustrates a simplified side view of an apparatus, in accordance with one embodiment of the invention. In **Fig. 1**, an apparatus **100** includes a mask **102** and a mask platform **104**. As shown, the mask **102** is disposed on the mask platform **104**, and accordingly, between the mask **102** and the mask platform **104** is an interface **106**. Additionally, shown in **Fig. 1** are one or more electrical conductors **108** included within the mask platform **104**. In the illustrated embodiment of **Fig. 1**, the apparatus **100** includes a temperature differential device **110**.

[0011] In **Fig. 1**, the electrical conductors **108** may provide a predetermined holding force between the mask **102** and the mask platform **104** in the form of electrostatic forces between the mask **102** and the mask platform **104**. In accordance with various embodiments of the invention, the predetermined holding force between the mask **102** and the mask platform **104** may be released by reversing the polarity of the of the electrostatic forces. In the embodiment illustrated in **Fig. 1**, once the predetermined holding force between the mask **102** and the mask platform **104** is released, the temperature differential device **110** provides a temperature differential at the interface **106** between the mask **102** and the mask platform **104**, which in turn, facilitates separation of the mask **104** and the mask platform **102**.

[0012] As shown in **Fig. 1**, the temperature differential device **110** may be a gas deliver device such as, but not limited to, a nozzle in accordance with one embodiment. The gas that is delivered to the interface **106** may be any type of gas such as, but not limited to, a low temperature gas. Further, the gas may be a noble gas that minimizes potential reactions with the various coatings and/or materials of the mask **102** and/or the mask platform **104** such as, but not limited to nitrogen.

[0013] In the illustrated embodiment of **Fig. 1**, the mask **102** and the mask platform **104** may be a mask and a mask platform compatible with use in extreme ultraviolet (EUV) radiation lithography environment. Accordingly, mask **102** and the mask platform **104** may be utilized in a high vacuum environment having a vacuum of approximately 10E-8 Torr or lower. As shown in **Fig. 1**, the mask platform **104** may be utilized to hold the mask **102** by electrostatic forces in the EUV environment. Accordingly, in the EUV radiation lithography environment, mask **102** may have various coatings such as, but not limited to, chromium to facilitate electrostatic forces. That is, the mask **102** may various coatings on the side facing the interface **106** to facilitate the holding forces between the mask **102** and the mask platform **104**. In turn, the mask platform **104** may have various coatings such as, but not limited to, adhesive type coatings to facilitate stable coatings at the interface **106**. In the EUV radiation lithography environment, relatively high holding forces may be utilized between the mask **102** and the mask platform **104** such as, but not limited to about 15 kPa (i.e., the mask platform **104** may exert a force upon the mask **102**). Additionally, the EUV radiation may be radiation **112** from a radiation source (not shown) having wavelengths

in the range of about 11-14 nm. As shown, the radiation **112** is commonly directed towards the mask **102**.

[0014] The mask **102** and the mask platform **104** may be made of a material commonly utilized in EUV radiation lithography environments. For example, the mask **102** and the mask platform **104** may be made of low thermal expansion materials such as, but not limited to Zerodur™ provided by Schott Glass Corporation of Mainz, Germany and ULE™ provided by Corning Incorporated of New York, New York. Additionally, the mask **102** and the mask platform **104** may have various reflective type coatings commonly utilized in EUV radiation lithography environments such as, but not limited to, Molybdenum/Silicon (Mo/Si) multilayer (ML) reflective coatings to facilitate reflection of EUV radiation as shown in **Fig. 1**. The mask **102** may also have various EUV radiation absorbing coatings such as, but not limited to, titanium nitride, tantalum nitride, and any combination thereof, which may be disposed over the Mo/Si ML coatings, and various features may be patterned on the various EUV radiation absorbing material.

[0015] In various embodiments, the mask **102** and the mask platform **104** may be held together by predetermined holding forces in the form of electrostatic forces that may be substantial, as previously described. The electrodes **108** provide electrostatic holding forces. That is, the mask platform **104** may be provided with one electrical potential through the one or more electrodes **108** aids in holding the mask **102** onto the mask platform **104**. As previously described, the mask **102**, in particular at the interface **106**, may have various coatings such as, but not limited to, electrically conductive coating such as Chromium (Cr) to facilitate substantial and stable holding forces.

Accordingly, in order to release the mask **102** from the mask platform **104**, the electrostatic holding forces may be released (i.e., remove pressure and provide a second electrical potential through the electrodes **108**, which may be a reversal of an electrical potential to form a reverse force). However, the mask **102** and the mask platform **104** may not release in a timely manner, and this may be due to various surface tension affects which may be exacerbated by the various adhesive coatings on the mask interface **106**, as previously described. That is, the surface tension may be relatively high due to substantially flat surfaces of the mask **102** and the mask platform **104** at the interface **106**.

[0016] There may be various factors that affect the release of the mask **102** and the mask platform **104** (i.e., reasons why they continue to stick together even after the reverse force is applied). For example, when substantially flat surfaces are interfaced with each other for a period of time, the interface may have very small particles, air, or water that may be trapped resulting in very small vacuum like mechanisms. Further, the effects of these very small vacuum like mechanisms may be enhanced by the electrodes **108** within the mask platform **104**. The addition of the various coatings may further to increase the sticking together of the mask **102** and the mask platform **104**. Accordingly, in the one embodiment of **Fig. 1**, the temperature differential device **110** provides a temperature differential (e.g., a low temperature gas) at the interface **106** between the mask **102** and the mask platform **104** to facilitate separation of the mask **102** and the mask platform **104**.

[0017] In **Fig. 1**, two thermal differential devices **110** are shown. However, it should be appreciated by those skilled in the relevant art that the number of thermal

differential devices may be any number and of varying configurations to provide a thermal differential to the interface **106** between the mask **102** and the mask platform **104**. Application of the thermal differential devices **110** in proximity to the interface **106** between the mask **102** and the mask platform **104** facilitates separation of the mask **102** and the mask platform **104** due to various thermal effects on the various adhesive mechanisms, as previously described. For example, thermal effects of contractions and/or embrittlement of the various coatings and the vacuum like mechanisms helps to reduce the sticking together of the mask **102** and the mask platform **104**.

[0018] **Figure 2** illustrates an apparatus for facilitating separation of a mask and a mask platform, in accordance with another embodiment. Shown in **Fig. 2**, is a top view of an apparatus **200**. The apparatus **200** includes a mask platform **202**, and the mask platform **202** includes a channel **204** embedded within the mask platform **202**. In the illustrated embodiment of **Fig. 2**, together, the apparatus **200** having the mask platform **202** and the channel **204**, may operate as a temperature differential device. That is, a temperature differential device is integrated with the mask platform **202**.

[0019] Continuing to refer to **Fig. 2**, in various embodiments, a predetermined holding force between a mask **102** (shown in **Fig. 1**) and the mask platform **202** may be released, as previously described. Once the predetermined holding force has been released, a temperature material may be provided through the channel **204**, thereby providing a temperature differential between the mask (not shown) and the mask platform **202** having the channel **204**, and which in turn, facilitates separation of the mask **102** (shown in **Fig. 1**) and the mask platform **204**. The channel **204** may be

coupled to a circulation device (not shown) to receive various materials having varying thermal properties to provide a thermal differential to the mask platform **202**.

[0020] The material may be any type of temperature material such as, but not limited to a low temperature material (e.g., a gas and/or a liquid). Additionally, in the illustrated embodiment of **Fig. 2**, because the channel **204** may be fully enclosed within the mask platform **202**, the material may be a wide variety of materials. The material provided within the channel **204** provides the thermal differential at the interface **106** between the mask **102** (both shown in **Fig. 1**) and the mask platform **202**. That is, because the material may be fully enclosed, any material that provides a temperature differential to facilitate separation of the mask **102** (shown in **Fig.1**) and the mask platform **202** may be utilized including various reactive materials. Additionally, as previously described, the material may be circulated through the channels **204** by a circulation device (not shown).

[0021] As previously described, the apparatus **200** may also be utilized in a EUV radiation lithography environment. Additionally, the apparatus **200** may include one or more electrodes **108** (shown in **Fig. 1**). It should be appreciated by those skilled in the relevant art that the manner in which the channel **204** may be disposed within the mask platform **202** may be based at least in part on the relative locations of the electrodes (shown in **Fig. 1**), and may be application dependent. Accordingly, the mask platform **202** may have more than one channel **204** in a variety of configurations.

[0022] **Figures 3a-3b** illustrate various views of an apparatus for facilitating separation of a mask and a mask platform, in accordance with another embodiment. In **Fig. 3a**, a side view of an apparatus **300** is shown. The apparatus **300** includes a mask

302, a mask platform **304**, and one or more electrodes **308**. The mask **302**, the mask platform **304**, and the one or more electrodes **308** may be similar to the previously described in **Figs. 1-2**. Accordingly, the one or more electrodes **308** may be disposed within the mask platform **304**, and between the mask **302** and the mask platform **304** is an interface **306**. However, in **Fig. 3a**, the mask platform **304** includes a thermal differential device **310** that is disposed to substantially penetrate through the mask platform **304**.

[0023] Continuing to refer to **Fig. 3a**, in the illustrated embodiment, the thermal differential device **310** is shown as one or more pathways **312** that pass through the mask platform **304** and extends into the interface **306**. Further, the one or more pathways **312** may be interconnected by a central connecting pathway **314**. A material such as, but not limited to, a low temperature material may be provided through the connecting pathway **314**, which in turn, provides the material to the one or more pathways **312**. The material provided in the one or more pathways **312** provides a temperature differential between the mask **302** and the mask platform **304**, thereby facilitating separation of the mask **302** and the mask platform **304**. That is, the temperature differential is provided to the interface **306** aids in overcoming various surface tension affects that may be enhanced by various coatings to facilitate timely separation of the mask **302** and the mask platform **304**.

[0024] Referring now to **Fig. 3b**, which is a view of the mask platform **304** from the mask **302** side, the one or more pathways **312** may be patterned on the mask platform **304** as shown. Here again, the patterning of the one or more pathways **312** may be based at least in part on the type and configuration of the mask platform **304**.

For example, the pattering of the one or more pathways **312** in **Fig. 3b** may be located to avoid one or more electrodes **308** (shown in **Fig. 3a**).

[0025] **Figure 4** illustrates an apparatus for facilitating separation of a mask and a mask platform, in accordance with another embodiment. Shown in **Fig. 4** is a side view of an apparatus **400** that includes a mask **402**, a mask platform **404**, and an interface **406** between the mask **402** and the mask platform **404**. On the mask platform **404** is shown a simplified view of a thermal differential device **408**. In the embodiment illustrated in **Fig. 4**, the thermal differential device **408** may be a Peltier type of device. That is, a device that absorbs or produces heat based at least in part on the direction of electrical current. Accordingly, based at least in part on the electrical current provided to the thermal differential device **408**, the thermal differential device **408** may provide a thermal differential to facilitate the separation of the mask **402** and the mask platform **404** (i.e., thermal differential to the interface **406**). The electrical current may be provided by a variety of manners such as, but not limited to, an electrical current that may be provided to the one or more electrodes, previously described.

[0026] It should be appreciated by those skilled in the art that the apparatuses **100-300** illustrated in **Figs. 1-4** may be a portion thereof, and does not necessarily show the entire apparatuses utilized in lithography for manufacturing of integrated circuits such as, but not limited to semiconductor devices. Accordingly, in order to not obscure the various embodiments of the invention, various optical components, devices, and so forth have been omitted. Further, the apparatuses **100-400** may be utilized in a variety of lithography techniques. Accordingly, the mask and the mask platforms illustrated may be any shape and size and may be application dependent. Additionally, the

material that provides a temperature differential may be any type of material and may be based at least in part on the material of the mask and/or the mask platform. That is, the temperature differential may be hot or cold and any combination thereof.

[0027] Having described and illustrated the principles of the invention with reference to illustrated embodiments, it will be recognized that the illustrated embodiments can be modified in arrangement and detail without departing from such principles. And, though the foregoing discussion has focused on particular embodiments, other configurations are contemplated. In particular, even though expressions such as "in one embodiment," "in another embodiment," or the like are used herein, these phrases are meant to generally reference embodiment possibilities, and are not intended to limit the invention to particular embodiment configurations. As used herein, these terms may reference the same or different embodiments that are combinable into other embodiments.

[0028] Thus, it can be seen from the above descriptions, a novel method and apparatus to facilitate separation of a mask and mask platform has been described.

[0029] The above description of illustrated embodiments of the invention, including what is described in the Abstract, is not intended to be exhaustive or to limit the invention to the precise forms disclosed. While specific embodiments of, and examples for, the invention are described herein for illustrative purposes, various equivalent modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize. Thus, the description is to be regarded as illustrative instead of restrictive on the invention.

[0030] Consequently, in view of the wide variety of permutations to the embodiments described herein, this detailed description is intended to be illustrative only, and should not be taken as limiting the scope of the invention. What is claimed as the invention, therefore, is all such modifications as may come within the scope and spirit of the following claims and equivalents thereto.